



Robot Task Space Analyzer

Technology Need:

Many Department of Energy (DOE) environmental restoration and waste management projects will involve radiation or other hazards that necessitate the use of remote operations to protect human workers from dangerous exposures. Remote work is slow and tedious due to difficulties of remote manipulation and viewing. Facility deactivation and decommissioning (D&D) involves complex cutting, handling, and sorting tasks that may take tens-to-hundreds of times longer than equivalent hands-on work. New and fundamental technologies are needed to increase the efficiency of remote operations and reduce costs.

Technology Description:

The University of Tennessee (UT) has developed a promising way to achieve increased remote work-system efficiency by layering telerobotic technologies onto teleoperated remote systems. The best available remote work-systems use pure teleoperation in which a single human operator performs all operations through remote control and viewing interfaces. Telerobotics research seeks to improve this baseline by allowing operators to automate sub-tasks. Sub-task automation will decrease task time while enhancing safety and work quality.

Before Sub-task automation can be exploited, it is necessary to model the 3-D geometry of the task space scene surrounding the remote work-system. This precision description of where objects are located in the task space is rarely available beforehand. It must be generated at the work site by interactive sensor systems associated with the robot. The Robot Task Space Analyzer (RTSA) is a potential integrated sensor subsystem capable of obtaining the data necessary for Sub-task automation.

RTSA is a collection of software processes running on a computer in the operator's console and linked to physical devices on remote worksystems. It is organized into modules that provide a full spectrum of options to the operator for the comparatively fast and efficient creation of task space 3-D models.

The RSTA combines laser and stereo imaging, human-interactive modeling, and semi-automatic object recognition to build a 3-D model of the work



zone in which a robot system is operating. In future telerobotic worksystems, RTSA results will be accessed by automatic collision checking and motion planning routines to automate subtask execution.

Prior work in human-interactive stereo at the Oak Ridge National Laboratory (ORNL) and interactive 3-D object recognition from laser range camera images at the Carnegie Mellon University will be used as a foundation for RTSA. The project will emphasize the human factors aspects of the interactive software.

Benefits:

RTSA will reduce the costs of operating remote equipment in D&D projects by:

- <Reducing remote task execution time
- <Reducing the number of system operators
- <Improving work quality in repetitive and tedious tasks
- <Facilitating enhanced operational safety

RTSA is an enabling technology necessary for the deployment of telerobotic automation in D&D. It is conservatively estimated that effective telerobotics systems can increase the productivity of D&D remote operations by 10 to 30%. If only 10% of the projected D&D projects involve remote operations, telerobotic savings enabled through the RTSA could be in the range from tens to hundreds of millions of dollars.

Status and Accomplishments:

This project was completed in May 2000. Research and development of the RTSA was conducted over two phases. Phase I was completed in September 1999. During this phase laboratory scale components of the RTSA were developed and evaluated. A laboratory test demonstration was performed on September 16, 1999. The test involved a number of representatives from Sandia National Laboratory, ORNL, Idaho National Engineering and Environmental Laboratory, the University of Michigan, Savannah River Technology Center, Albuquerque Operations Office, DOE Headquarters-EM, and the National Energy Technology Laboratory. Initial test results indicated that RTSA has the ability to construct models of a task space scene analysis layer on the order of minutes. The Sub-task time fits within the Sub-task execution operation cycle.

Phase II work involved further implementation and detailed evaluation of a complete RTSA system. Tests

were performed on several task mock-ups with multiple subjects and trials. It was found that RTSA in its present configuration allows significantly large piping structures to be modelled with an accuracy of ± 1 inch in matters of minutes. These results are well within the time cycle of routine teleoperations constraints. These results are well within the success goals set for RTSA.

The RTSA system is in the process of being integrated with the Oak Ridge National Laboratory's dual arm telerobotics test bed project that will be used to analyze D&D and underground storage tank riser pit operational enhancement project opportunities involving telerobotics.

Contacts:

William R. Hamel
University of Tennessee
Phone: (423) 974-6588
E-mail: whamel@utk.edu

Vijendra P. Kothari
National Energy Technology Laboratory
Phone: (304) 285-4579
E-mail: vijendra.kothari@netl.doe.gov

Online Resources:

Office of Science and Technology, Technology Management System (TMS), Tech ID # 2171
<http://ost.em.doe.gov/tms>

The National Energy Technology Laboratory Internet address is <http://www.netl.doe.gov>

For additional information, please visit UT's website: <http://www.utk.edu/>